MINIATURE FAN OR MICRO-FAN

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FIELD OF THE INVENTION:

The invention relates to a miniature fan or micro-fan that is driven by an electronically commutated external-rotor motor.

BACKGROUND:

Miniature fans or micro-fans serve, for example, to cool processors in computer, to cool small devices, etc., and they have very small dimensions. For example:
fans of PAPST series 250 have dimensions of 8 x 25 x 25 mm,
those of PAPST series 400F, dimensions of 10 x 40 x 40 mm,
those of PAPST series 400, 20 x 40 x 40 mm,
those of PAPST series 500, 50 x 50 x 15 mm, and
those of PAPST series 600, 60 x 60 x 25 mm.

The power consumption of such fans is 0.4-0.6 W for series 250, 0.7-0.9 W for series 400F, 0.9-1.6 W for series 400, and 0.8-3.4 W for series 600. This defines the preferred field of application of the present invention.

In fans that are driven by an electronically commutated external-rotor motor, the motor is large in relation to the overall size of the fan, which is disadvantageous in terms of the flow rate (V/t) and pressure increase Δp of the fan.

SUMMARY OF THE INVENTION:

It is therefore an object of the invention to make available a new miniature fan or micro-fan.

According to the invention, this object is achieved by arranging a rotor position sensor centrally but other control components outside the air duct. It is thereby possible to mount the at least one rotor position sensor in space-saving fashion on the motor region of the circuit board configuration, and to arrange other components in a component region outside the air duct, thus allowing the annular air flow cross section to be made larger than previously. This

permits larger fan blades to be used, and thus a greater flow rate and/or a greater pressure increase to be achieved for the same physical size.

Another manner of achieving the stated object is to arrange a motor region, of the control circuit board, on an inner side of the air duct between the carrier hub and the claw-pole stator. The combination according to this claim results, even in micro-fans, in very favorable values for flow rate and pressure increase, which are increasingly in demand nowadays. A compact design with a large annular air flow cross section, and consequently a particularly large flow rate, is thus obtained, so that a configuration of this kind according to the invention represents a particularly advantageous combination for miniature fans and micro-fans.

These approaches to achieving the object of the present invention create the possibility of increasing the number of functions for a miniature fan or micro-fan. For example, when miniature fans or micro-fans are used in open- or closed-loop control systems or management systems, they must not generate any electromagnetic interference, i.e. their electromagnetic compatibility (EMC) must meet high standards; this requires more components and more-complex circuits, which the invention now makes possible for the first time in compact form for miniature fans and micro-fans as well.

With the invention, it is also possible to integrate into the circuitry of such a fan additional functions that are now increasingly in demand, e.g. PWM open- and closed-loop control systems, analog rotation speed controllers, digital rotation speed controllers, programmable rotation speed controllers, switching thresholds for analog control systems, etc. This also allows reliable control of a miniature fan or micro-fan via a data bus such as those now common, for example, in motor vehicles.

Further details and advantageous refinements of the invention are evident from the exemplary embodiments, in no way to be understood as a limitation of the invention, that are described below and illustrated in the drawings.

BRIEF FIGURE DESCRIPTION:

FIG. 1 is a plan view of a double fan comprising two miniature fans or micro-fans, at very greatly enlarged scale;

FIG. 2 is an individual depiction of a circuit board used in the double fan of FIG. 1;

FIG. 3 shows a first embodiment of an individual miniature fan or micro-fan in which most of the electronic components are housed in a lateral housing part, the connection from the motor to the lateral components being accomplished via a flexible conductor;

FIG. 4 shows a second embodiment of a miniature fan, viewed in the direction of arrow IV of FIG. 5, in which most of the electronic components are housed in a lateral housing part, the connection from the motor to the lateral components being accomplished via a rigid conductor;

FIG. 5 is a section viewed along line V-V of FIG. 4;

FIG. 6 shows a third embodiment of a miniature fan, viewed in the direction of arrow VI of FIG. 7, in which most of the electronic components are housed in a narrow lateral housing part and the connection from the motor to the lateral components is accomplished via flexible stranded conductors;

FIG. 7 is a section viewed along line VII-VII of FIG. 6; and

FIG. 8 depicts a micro-fan according to the present invention at approximately actual size.

DETAILED DESCRIPTION:

FIG. 1 shows, at greatly enlarged scale, a double fan 20 comprising a housing 22 in which two miniature fans or micro-fans 24, 26, each driven by an electronically commutated external-rotor motor 28, 30, are arranged next to one another. These motors 28, 30 are rigidly connected to housing 22 by way of struts (not depicted).

According to the invention and as shown in FIG. 2, a circuit board 32 that has, for motor 28, a first approximately annular part 34, on which a Hall IC 36 and four attachment points 38 for the winding ends of motor 28 are provided, is used in the double fan of FIG. 1. Part 34 is connected, via a first bridge 40 comprising printed conductors (not depicted), to a second approximately annular part 42 on which are located a Hall IC 44 and four attachment points 46 for the winding ends (not depicted) of motor 30.

Part 42 is connected, via a second bridge 48 comprising printed conductors (not depicted), to an (in this case, rectangular) part 50 on which most of the electronic components of the two motors 28, 30 are arranged. The connection to motors 28, 30 is accomplished via printed conductors (not depicted) on parts 34, 40, 42, 48, and 50.

Bridges 40, 48 are preferably arranged in such a way that they each extend under a strut that respectively connects motor 28, 30 to housing 22. For that purpose they can also, as applicable, extend obliquely.

FIG. 3 depicts an analogous arrangement 60 comprising a single miniature fan 62, implemented as an axial fan, that is shown greatly enlarged. This fan has a hub 64 that is connected via struts 66 to a housing 68. Mounted on this hub 64 is an external-rotor motor 70 that has an internal stator 72 having claw poles 74 and an annular winding 76. Rotating around internal stator 72 is an external rotor 80 having a rotor cup 82 made of plastic, into which is injection-embedded a magnetic yoke ring 84 on which is arranged an annular permanent magnet 86 that is radially magnetized. The blades of

fan 62 are labeled 106, and are mounted on rotor cup 82. Located between internal stator 72 and hub 64 is a circuit board 90, connected to which electrically and mechanically is a flexible conductor 92 that leads to a circuit board 94 and is electrically and mechanically connected thereto. Most of the electronic components 96 of motor 70 are located on circuit board 94, with the exception of a Hall IC (not depicted) that is arranged on circuit board 90 in the region of the magnetic field of rotor 86, and is controlled by that magnetic field.

Circuit board 94 with its components 96 is located in a lateral housing part 98 that, after assembly, is sealed by a cover 100 on which circuit board 94 is secured by means of support members 102.

It is advantageous here that with this arrangement, cover 100 can be swung down to the right for assembly; and that after assembly, it can be connected in liquid-tight fashion to part 98. Flexible conductor 92 thus enables problem-free assembly.

FIGS. 4 and 5 show a miniature fan 110 comprising an approximately rectangular housing 112 that has an air duct 114 in which hub 118 of an external-rotor motor 120 is held by struts 116. As in FIG. 3, motor 120 has an internal stator 122 with claw poles 124 and an annular winding 126. An external rotor 128, on which five fan blades 130 of an axial fan are provided, rotates about internal stator 122.

A rigid circuit board 134, whose shape is indicated with dashed lines in FIG. 4, extends between hub 118 and internal stator 122. Circuit board 134 is approximately annular in the region between hub 118 and internal stator 122, and it carries there a Hall IC (not depicted) as well as connecting points for the attachment of annular winding 126. The reader is referred to the analogous depiction in FIG. 2.

From the annular portion of circuit board 134, a narrow bridge 136 goes to a larger, approximately rectangular part 138 on which the essential electronic components 140 of motor

120 are arranged (see FIG. 5). This part 138 is located in a space 144 that can be sealed by a cover 142.

As is directly apparent, circuit board 134 populated with components 140 can be very easily installed before cover 142 is put in place.

Housing 112 is equipped with four openings 148 for mounting it.

FIGS. 6 and 7 show, once again greatly enlarged, a miniature fan or micro-fan comprising a housing 150 in which is provided an air duct 152 in which hub 156 of a claw-pole external-rotor motor 158, whose external rotor 160 carries five blades 162, is mounted by means of struts 154.

Located between hub 156 and motor 158 is an annular circuit board 163 that, similarly to FIG. 2, carries a Hall IC (not depicted) and attachment points for stator winding 164 of motor 158.

Also provided, to the side of air duct 152, is a housing part 166 in which a circuit board 168 having electronic components 170 of motor 158 is mounted. Housing part 166 is closed after assembly by a cover 172.

The connection from circuit board 163 to circuit board 168 is accomplished here by means of flexible electrical conductors 174, called stranded conductors, that are permanently soldered onto the two circuit boards 163 and 168. Stranded conductors of this kind can be mounted particularly easily on a strut 154 of fan housing 150.

FIG. 8 shows a micro-fan 200 according to the invention. A one-centimeter length is indicated at the left as a scale; in other words, fan 200 is shown slightly enlarged. It has external dimensions of 35 x 40 x 8 mm, and a weight of approx. 5 g. Five fan blades 204 are arranged externally on its motor 202. The motor has a power consumption of 0.5 W and a rated rotation speed of 9000 rpm. Viewed as depicted in FIG. 8, fan 200 runs counterclockwise and blows toward the back.

Housing 150 of fan 200 has, on the right side as depicted, an enlargement in which circuit board 168 with (schematically indicated) electronic components 170 is located (see FIG. 7). The lateral enlargement is closed by cover 172, but in some cases can also be open. The connection from circuit board 168 to motor 202 is preferably accomplished in the manner depicted, in greatly enlarged fashion, in FIGS. 6 and 7.

Because components 170 are not arranged directly inside motor 202 but instead in the lateral enlargement of housing 150, the diameter of motor 202 can be correspondingly reduced, e.g. from 17.5 to 13.5 mm. With only slightly greater dimensions for housing 150, the flow rate V/t of fan 200 for a given static pressure Δpf thus rises approximately 80 to 110%, e.g. from 1.5 m^3/h to 3.2 m^3/h. The invention thus allows an improved flow rate, and consequently better cooling performance, to be obtained in such micro-fans with very simple means.

Aspects common to all the approaches depicted are that they greatly simplify, even for very small fans, assembly of the electronics for the fan's electronically commutated drive motor; that the volume and weight of the fan are not substantially increased; and that they enable new fan electronics functions for miniature fans and micro-fans of this kind.

Lateral installation of the motor electronics further allows the size of the motor hub to be reduced, i.e. the cross section for air passage, and therefore the fan performance and pressure increase of the fan, can be very easily increased by means of the invention.

Many variants and modifications are of course possible within the scope of the present invention.